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VOLATILITY SPILLOVER AND INVESTOR SENTIMENT: SUBPRIME CRISIS

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ABSTRACT

In this paper, we test the role of the American investor sentiment in the amplification of the subprime financial crisis by examining the volatility spillover between the Standard & Poor's 500 Index (S&P 500) returns and investor sentiment measures. We show a significant effect of investor sentiment variation on return and volatilities, and we reveal the contribution of returns shocks to the variability of investor sentiment variation during the subprime crisis. Moreover, we notice the determinant role of investor sentiment in the amplification of the subprime financial crisis by the intense spillover of volatility from investor sentiment to returns. Our finding indicates that investors can use investor sentiment as an indicator to predict returns-volatility.

Keywords: investor sentiment, volatility spillover, subprime crisis, DCC-GARCH, variance decomposition, BEKK-GARCH

INTRODUCTION

Investor sentiment, like optimism, fear and panic, depends largely on stock price movements, especially during periods of high volatility. Indeed, this tranquil period characterised by an increase of stock prices enlarges the investors' optimism. However, during crisis periods, a sentiment of fear and panic is observed in financial markets. The US financial market has witnessed a high volatility period: the subprime crisis period. The subprime financial crisis that started in mid-2007 is considered one of the most serious and dramatic international financial crises of recent decades. Thus, this crisis may influence the relation between investor sentiment and returns.

The study of the impact of investor sentiment on prices dynamics in financial markets is considered a central focus in behavioural finance. Two main issues on this topic are often considered. A growing number of empirical studies (Fisher & Statman, 2000; Baker & Wurgler, 2007; Schmeling, 2009) primarily

explore the relation between investor sentiment and returns. In fact, most studies suggest the existence of a negative relation between investor sentiment and expected returns. However, other recent studies (Yu & Yuan, 2011; Kling & Gao, 2008) investigate the relation between investor sentiment and the volatility of return.

Investor sentiment, which can be defined as the feelings or attitudes of investors towards a security market or all financial markets, can be transmitted to financial markets through its transactions and choices. Behavioural biases, like loss aversion, pessimism and herding, can drive the market during a crisis period or one of political instability from bullish to very bullish. Thus, if investor sentiment has spillover effects on returns, we can anticipate market reactions during a crisis period, which is an important issue for analysts, fundamentalists and investors. Indeed, during a crisis period, an investor can correctly comprehend the dramatic decrease of prices and behave correctly in such a case without following the behaviour of the others investors. In the same context, if returns present spillover effects on investor sentiment, we expect a variation of investor sentiment, which can imply a variation of stock prices.

Behavioural finance allows for better analysing and understanding the volatility and occurrence of financial crises according to the behaviour of investor sentiment. In fact, research in recent decades illustrates the role of behavioural biases, like loss aversion (Agarwal, 2008), extrapolation, herding and overconfidence (Redhead, 2008), in explaining the occurrence of the subprime and dot.com financial crises. Similarly, the feeling, mood and belief of the investor influence the probability of the occurrence of financial crises (Zouaoui, Nouyrigat, & Beer, 2010).

An analysis of the literature shows that the relation between investor sentiment, stock market returns and volatility has received much attention, but there is a lack of evidence regarding this relation during the subprime crisis. Moreover, the volatility spillover between American investor sentiment and index returns remains uninvestigated during the subprime financial crisis. Therefore, in this study, our main objective is to empirically examine the volatility spillover between American investor sentiment and stock market returns.

First, we examine both the relation between investor sentiment and price dynamics and the dynamic correlation between investor sentiment and returns. Second, we examine the effect of investor sentiment variation on stock market returns. Furthermore, we examine the effect of investor sentiment variation on return volatilities by estimating an augmented GARCH model. Then, we analyse the effect of returns shocks on investor sentiment variation by examining the

forecast variance decomposition. Finally, we focus on the volatility spillover between American investor sentiment and index returns by estimating the bivariate BEKK-GARCH model.

Our main contribution is to empirically investigate the role of investor sentiment in the amplification of the subprime financial crisis.

LITERATURE REVIEW

There is a large body of existing literature on investor sentiment. Several psychological studies suggest that investors' choices are influenced by emotional, cognitive and psychological factors. In this context, behavioural models, like Prospect Theory (PT), have been developed. According to Kahneman and Tversky (1979), the prospective value function of Prospect Theory is concave over gains (risk aversion for gains) and convex over losses (risk seeking for losses), and it is steepest in the loss domain. Prospect theory arguments have been increasingly used to explain phenomena observed in financial markets, such as the disposition effect, momentum (Menkhoff & Schmeling, 2006), excess of volatility, stock return predictability, and the equity premium puzzle. Using Prospect Theory, many studies, including those by Benartzi and Thaler (1995) and Abdelhédi-Zouch, Boujelbéne-Abbes and Boujelbéne (2012), propose an explanation of the equity premium puzzle using two behavioural concepts: loss aversion and mental accounting. Abdelhédi-Zouch et al. (2012) find that during a subprime crisis, the loss-averse investor becomes less attractive to risky assets.

Moreover, studying the relation between investor sentiment and returns, Baker and Wurgler (2006) find evidence of a significant effect of investor sentiment on cross-section returns. This effect is stronger on small, younger, unprofitable, high-growth and non-dividend-paying firms. Kling and Gao (2008) find that the Chinese investor sentiment follows a positive feedback process. Indeed, lagged positive returns lead optimism in the market. However, lagged negative returns lead pessimism in the financial market. Schmeling (2009) suggests the existence of a significant relation between sentiment and expected returns.

A growing number of empirical studies infer the influence of investor sentiment on the volatility of returns. Kling and Gao (2008) study the impact of investor sentiment and conditional variance of investor sentiment on the conditional variance of stock returns. Their results confirm a significant relation between investor sentiment and the conditional variance of stock returns, but reject the volatility spillover between Chinese investor sentiment and returns. Chuang, Ouyang, and Lo (2010) document a negative relation between volatility

and returns in the Taiwanese market. Qiang and Shu-e (2010) find that the fluctuation of investor sentiment asymmetrically affects the fluctuation of stock prices. Indeed, the change of stock prices depends on positive or negative investor sentiment changes. These authors suggest that the volatility resulting from investor sentiment changes represents systematic risk. Yu and Yuan (2011) analyse the effect of investor sentiment on the relation between returns and volatility. They find a negative correlation between volatility and returns during low-sentiment periods.

The crisis appearance attracts authors' attention to study the effects of investor behaviour during a crisis period. Redhead (2008) suggests that the dot.com bubble observed in the year 2000 was created due to the economic, financial and social factors and due to the effect of behavioural bias. He suggests that before the dot.com bubble, behavioural biases contributed to an increase in prices in financial markets. After, however, behavioural biases contributed to a dramatic decrease of prices, thus creating the bubble. Indeed, Hirshleifer (2001) indicates that in the stock market, investors follow the behaviours of other investors (herding bias) without any reason. In fact, stocks acquired by an investor provide useful information to other investors in that the price will continue rising in the future, encouraging them to buy these stocks (informational cascade).

In addition, the level of optimism in financial markets before the dot.com bubble influenced investment decisions (buying behaviour). Boswijk, Hommes and Manzan (2007) found that at the end of 1990, most investors followed the market trend (momentum). Thus, these behavioural biases contributed to an increase in prices in financial markets. However, in the year 2000, the market was marked by the introduction of several technology companies; consequently, the number of shares available on the market exceeded the number of shares requested by investors. Thus, technology companies have decreased the prices of their securities. This phenomenon leads to a decrease in prices in the financial market, which contributes to the emergence of a negative social mood in the market. Redhead (2008) suggests that financial markets have become dominated by very pessimistic investors who sell their undervalued stocks. Therefore, the decrease of sentiment (extrapolation of bad news) implies a decrease of stock prices, and the decrease of stock prices implies a decrease of sentiment (vicious circle).

The same behaviour is observed in financial markets during the subprime crisis. Behavioural biases, like optimism and herding, contribute to the increase of prices. However, the smallest decrease in prices, due to mortgage prices, implies a negative mood in the financial market. This negative mood, associated with herding and extrapolation, implies a dramatic decrease of prices.

DATA AND METHODOLOGICAL APPROACH

Data

This study uses daily S&P 500 index returns and investors' sentiment indexes. The sentiment indexes are the new implied volatility of the S&P 500 index (VIX), the new implied volatility for the Nasdaq 100 (VXN) and the put-call ratio.

The sample period is from January 1999 until January 2009. Because this period includes the subprime crisis period, we divided the sample period into two sub-periods: the tranquil period (from January 1999 to June 2007) and the period during the subprime crisis (from July 2007 to January 2010). The split of these periods is based on the results of the Chow breakpoints test (F-statistic = 514.525, probability = 0.000), which suggests that the subprime crisis started in the US in July 2007.

This study employs data from two sources: the closing price data of the S&P 500 market index provided by the Datastream database, and the data on VIX, VXN and put-call ratio sentiment indexes drawn from the Chicago Board Options Exchange.

VIX index

VIX is a key measure of the expected volatility of the S&P 500 index. The VIX Index represents a volatility index, which comprises options that reflect the market's expectation of future volatility over 30 calendar days (Chicago Board Options Change, CBOE, 2014). It is computed as the square root of the risk-neutral expectation of the S&P 500 variance over the next 30 calendar days, which is then annualised. VIX, originally developed by Whaley (1993), represents future market volatility on the prices of the S&P 100 for the next 30 days. In 2003, the Chicago Board Options Exchange introduced the new VIX of expected volatility for the next 30 days of the S&P 500 index (Whaley, 2009). The expected implied volatility is estimated by averaging the weighted prices of the S&P 500 puts and calls over a wide range of strike prices. For example, if the VIX is 20, this corresponds to an expected annualized standard deviation of less than 20% over the next 30 calendar days; therefore, the investor can suppose that the index option markets expect the S&P 500 to change up or down $20\%/\sqrt{12} = 5.78\%$. VIX is thus more broadly a gauge of investors' confidence on market movements and is dubbed as the investor fear gauge in financial markets. In fact, the VIX index reaches a high level in the bearish market and a low level in the bullish market.

VXN index

The new VXN reflects the investors' emotions, such as greed and fear, towards the financial market conditions. It aims to represent a measure of implied volatility for the Nasdaq 100 for the next 30 calendar days. It is calculated by the Chicago Board Options Exchange using the same methodology used to calculate the new VIX.

Put-call ratio

The put-call ratio is a contrarian investor measure in financial markets. A high level of put-call ratio indicates a strong pessimism in financial markets. However, a low level of put-call ratio indicates investors' optimism.

The put-call ratio, an indictor of investor sentiment, is calculated using the volume of puts options divided by the volume of calls options. The anticipation of falling prices in financial markets leads an investor to buy puts, consequently increasing the put-call ratio.

Methodological Approach

The impact of investor sentiment on stock prices and the contribution of this sentiment to crisis occurrence have become major topics in financial studies in recent years. Thus, we first inspect the dynamic movement of American investor sentiments and S&P 500 index prices.

The correlation between investor sentiment measures and returns depends on the number of positive and negative returns. Thus, we test the dynamic correlation between investor sentiment measures and returns using the Dynamic Conditional Correlation GARCH (Generalized Autoregressive Conditional Heteroskedasticity) model.

Engle (2002) introduced the DCC-GARCH model to measure the time varying correlation between series. In this context, we need the standardised residuals to measure the time varying correlation between investor sentiment measures and returns. We first use the GARCH (1,1) model to determine standardised residuals. These residual are then used for estimating the DCC-GARCH.

We then examine the effect of the dynamics of American investors' sentiment on the stock market return. Particularly, we test the relation between positive (negative) change of investor sentiment and the return of the S&P 500 index by estimating the following regression:

$$R_t = C + \alpha_1 \Delta(S_t) + \varepsilon_t \tag{1}$$

where R_t is the return of the S&P 500 index, S_t is the investor sentiment measure, and ΔS_t is the change of investor sentiment.

We next examine the effect of investor sentiment variation on return volatilities. Several empirical studies infer that investor sentiment predicts the volatility of returns. Kling and Gao (2008) added the investor sentiment in the mean and the variance equations of the GARCH model to test the effect of sentiment on returns and volatilities. Thus, we follow Kling and Gao (2008), and we test the augmented GARCH model, which includes only the variation of sentiment in the variance equation because the effect of investor sentiment in the return is tested in the previous estimation.

The augmented GARCH model is as follows:

$$\sigma_t^2 = w + \alpha_0 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \beta_2 \Delta S_t \tag{2}$$

where α_0 captures the ARCH coefficients, β_1 captures the GARCH coefficients and β_2 captures the effect of the change of investor sentiment (ΔS_t) on the conditional variance of returns (σ_t^2).

It is important to test the effect of returns on changes of investor sentiment. We then study the impact of return shocks on investor sentiment variation by employing the forecast error variance decomposition estimated from the VAR (Vector Autoregressive) model.

The current financial crisis presents a high volatility of investor sentiment. Thus, we finally investigate the volatility spillover between investor sentiment and returns by estimating the following bivariate GARCH-BEKK model:

$$\begin{aligned} R_t &= c_1 + \lambda_{11} R_{t-1} + \lambda_{12} S_{t-1} + \varepsilon_{1t} \\ S_t &= c_2 + \lambda_{21} R_{t-1} + \lambda_{22} S_{t-1} + \varepsilon_{2t} \end{aligned} \tag{3}$$

$$\varepsilon_t \left| \Gamma_{t-1} \right. \sim N(0, H_t) \tag{4}$$

where

$$H_t = \begin{pmatrix} h_{11,t} & h_{12,t} \\ h_{21,t} & h_{22,t} \end{pmatrix}$$

The BEKK parameters (Engle & Kroner, 1995) of the GARCH model are as follows:

$$H_t = \Omega'\Omega + \sum_{i=1}^{q} A_i' \varepsilon_{t-1}\varepsilon_{t-1}' A_i + \sum_{i=1}^{p} B_i' H_{t-1} B_i \quad (5)$$

where $\Omega = \begin{pmatrix} w_{11} & w_{12} \\ 0 & w_{22} \end{pmatrix}$, $A = \begin{pmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{pmatrix}$, $B = \begin{pmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{pmatrix}$, $h_t = \begin{pmatrix} h_{1t} \\ h_{2t} \end{pmatrix}$

where R_t represents returns of the S&P 500 index and S_t represents investor sentiment. λ_{12} represents the degree of mean spillover effects from the investor sentiment to the returns. λ_{21} represents the degree of mean spillover effects from the returns to the investor sentiment. Ω is a lower triangular matrix of constants. The symmetric matrix A captures the ARCH effects, while the matrix B focuses on the GARCH effects. B_{11} represents the GARCH parameters. α_{11} represents the ARCH parameters. α_{12} and β_{12} represent the degree of variance spillover effects from the investor sentiment to the returns. α_{21} and β_{21} represent the degree of variance spillover effects from returns to investor sentiment. In this paper, we assume $p = q = 1$. Volatility spillover is investigated by the significance of α_{11} and β_{11}.

EMPIRICAL RESULTS

Movement of Investor Sentiment Indexes and S&P 500 Returns

In this section, we focus on the time path of S&P 500 index prices and investor sentiment before and during the subprime crisis period. Figure 1 provides plots of the time path of S&P 500 index prices and the sentiment measures (VIX, VXN and put-call ratio) from January 1999 until January 2009.

We clearly show an inverse movement of investor sentiment measures and index prices. The decrease in index prices is associated with an increase in investor sentiment measures. Similarly, the increase in index prices is associated with a decrease in investor sentiment measures. Thus, the bear market exhibits strong panic and pessimism. However, when the market is bullish, an optimism sentiment dominates the financial market. Indeed, during the 2000–2002 technological crisis period, the VIX index reached 45 following the drop of index prices. Further evidence of inverse movement between investor sentiment and returns appears in the 2003–2006 period. During this tranquil period, we clearly show a reprise of investor confidence. In fact, this period is characterised by an

excess of optimism and investor confidence in financial markets. Indeed, the VIX and VXN indexes reached low values, approximately 15 and 20, respectively.

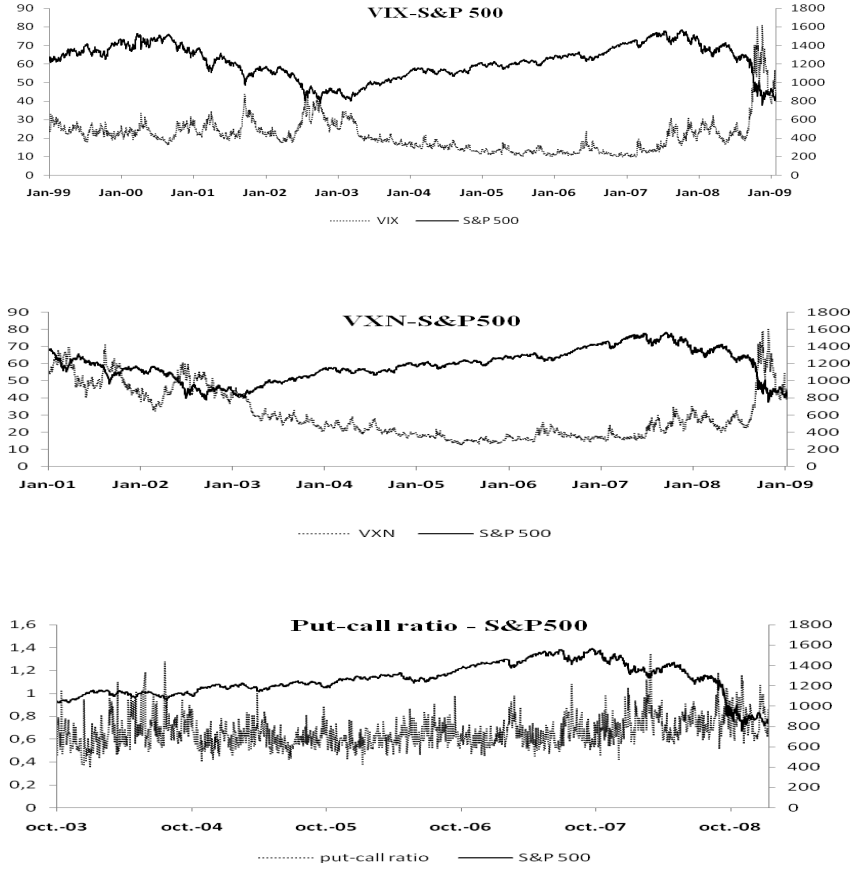

Figure 1. Movement of S&P 500 index prices and investor sentiment

The subprime financial crisis led to bankruptcy for many financial institutions listed in the U.S financial markets. Indeed, this crisis grew into a serious slump of stock prices, which led the VIX and VXN sentiment measures to increase and peak at the end of 2008. Indeed, during the subprime crisis, the VIX index exceeded 80, against 45 during 2000 and 2002. This maximum increase shows the high magnitude of the current financial crisis. We can conclude that the decline in prices during the subprime crisis caused a disruption in investor sentiment. The US financial markets experienced remarkable investor pessimism.

Therefore, the contribution of behavioral finance is very important for understanding the relation between stock prices and investor sentiment,

especially during the financial crisis. This result incites us to study the correlation between investor sentiment and returns.

Dynamic Conditional Correlation between Investor Sentiment and Returns

To make investment decisions, individual and institutional investors focus on the correlation between investor sentiment and returns. In this section, we analyse the dynamic correlation between returns and investor sentiment measures by estimating the DCC-GARCH model. Figure 2 plots the dynamic correlation between investor sentiment and index returns before and during the subprime crisis.

We find strong evidence of time with a varying negative correlation between S&P 500 index returns and investor sentiment. Some turmoil periods provide an extremely high negative correlation. However, some tranquil periods provide a low correlation between returns and sentiment. Indeed, during the 2003–2005 tranquil period, the correlation between returns and investor sentiment measured by VIX reached –0.18, while it reached –0.33 during the subprime financial crisis. Thus, negative returns have a greater effect on investor sentiment than positive returns. In addition, the subprime crisis led to more ripple effects on the correlation than the dot.com crisis. The magnitude of the fall in prices during the subprime crisis had a great effect on investor sentiment, especially on sentiment measured by the VIX and put-call ratio. Indeed, the VIX and put-call ratio sentiment measures had a larger negative correlation, –0.33 and –0.5, respectively, than those of the VXN index of –0.10 during the subprime crisis. Consequently, returns and investor sentiment measured by the implied volatility index exhibited a stronger negative correlation during low-sentiment periods (e.g., subprime crisis period). This finding confirms the results of Yu and Yuan (2011), suggesting that the negative correlation between returns and volatility is higher during low-sentiment periods.

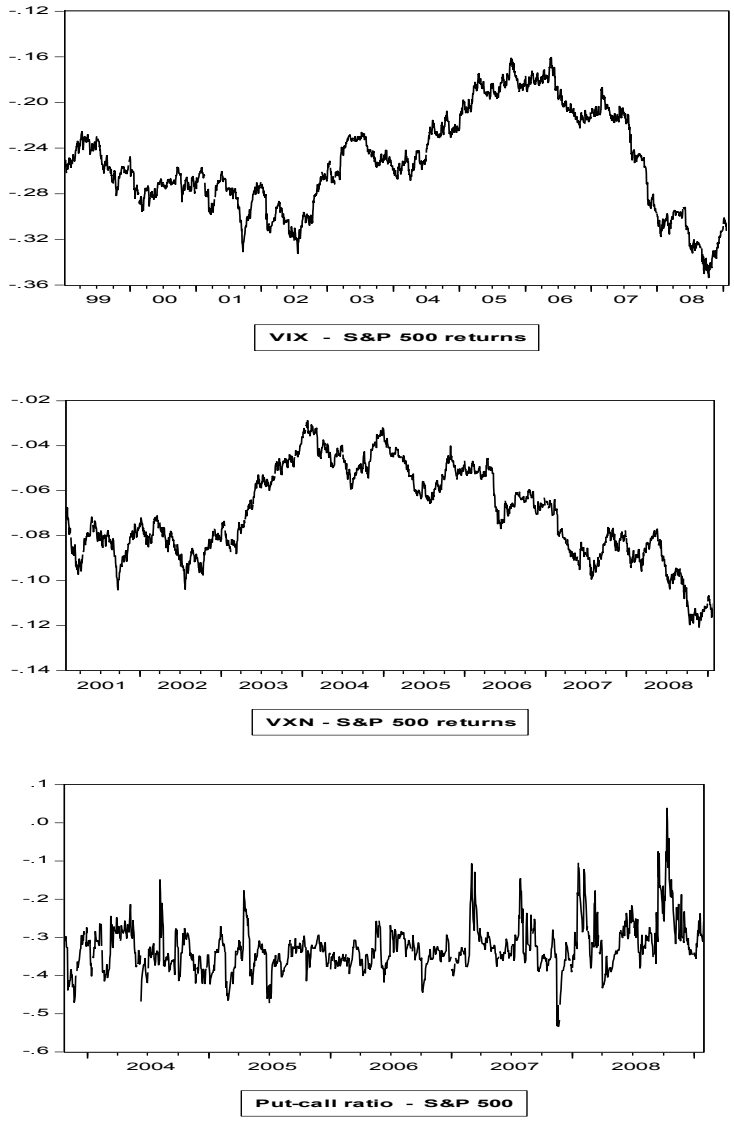

Figure 2. Dynamic correlation between S&P 500 index returns and investor sentiment

Relation between the Change of the Investor Sentiment and Returns

In this section, we examine the relation between investor sentiment variation and returns by estimating Equation 1. Table 1 illustrates the estimation results for the VIX, VXN and put-call ratio investor sentiment measures. Panel A reports the

results for the tranquil period, and Panel B reports the results during the subprime crisis.

Table 1
Impact of investor sentiment variation on index returns

	Panel A: Tranquil period			Panel B: During subprime crisis		
Horizon	VIX	VXN	(Put-Call) Ratio	VIX	VXN	(Put-Call) Ratio
C	0.0001	0.0001	0.0004*	–0.0007	–0.0008	–0.0013
	(0.8888)	(0.4986)	(2.0033)	(–0.7169)	(–0.7644)	(–1.1808)
α_1	–0.0072**	0.0001	–0.0163**	–0.0077**	–0.0074**	–0.0004
	(–60.4222)	(0.5364)	(–9.7566)	(–4.3138)	(–4.2724)	(–0.0560)

Note: *,**, denote significant at the 5% and 1% levels respectively. *t*-statistic is reported into parenthesis. The unit root test of Dickey-Fuller rejects the null hypothesis of a unit root in the series of index sentiment measures and returns.

We show that the changes of investor sentiment measures have a significant effect at the 1% level of the S&P 500 returns before and during the subprime crisis. This effect is significantly negative for sentiment measured by the VIX index and the put-call ratio before the subprime crisis and for the VXN and VIX indexes during the crisis period.

Thus, the increase in investor sentiment variations implies a decrease in the S&P 500 and, consequently, an increase in negative returns frequency. However, the decrease in investor sentiment variations implies an increase in the S&P 500 and, therefore, an increase in positive returns frequency.

The investor sentiment measured by the VIX has a slightly greater effect on returns during the subprime crisis than during the tranquil period. This effect is about –0.0072 before the crisis, and it is about –0.0077 during the crisis. These results occur because investor sentiment is more disturbed during the subprime crisis. Thus, the effect of change in investor sentiment on returns is higher during this period.

Relation between the Change in Investor Sentiment and Volatility

To examine the incremental ability of investor sentiment in affecting return volatilities, we estimate the augmented GARCH model, which includes the variation of sentiment in the variance equation (Equation 2). The estimation results are presented in Table 2. Panel A reports the results for the tranquil period, and Panel B reports the results during the subprime crisis.

The results reveal that the inclusion of the investor sentiment variation in the variance equation (β_3) is significantly positive before and during the subprime crisis. Before the subprime crisis, all measures of sentiment are significant at the 1% level. Thus, the increase in the variation of the VIX, VXN and put-call ratio reflects a disruption in investor sentiment. This unstable sentiment increases the irrational transactions, which consequently increase the volatility. Thus, we support the results of Lee, Jiang and Indro (2002), suggesting that investor sentiment presents a significant effect on volatility in the US financial markets.

During the subprime crisis period, the investor sentiment measured by VIX and VXN positively influences volatility in the US financial market. The disruption of investor sentiment following panic and fear sentiments on the impact of the subprime crisis on financial institutions and all other firms listed in financial markets reinforces investors to rapidly sell their stocks. This attitude during the subprime crisis implies a dramatic decrease in stock prices and a sharp increase in volatility.

The results of Table 2 show that the investor sentiment, measured by the put-call ratio, explains the volatility of returns only before the crisis. Thus, we can conclude that the VIX and VXN investor sentiment measures are appropriate indicators to predict volatility of returns both during tranquil and turmoil periods.

We clearly show that the contribution of return shocks on variability in investor sentiment variation is greater during the subprime crisis than during the tranquil period for sentiment measured by the VXN and put-call ratio. The impact of return shocks is slightly less than 10% on the put-call ratio during the tranquil period. Similarly, the returns shocks have a negligible impact on the VXN index. However, the contribution of return shocks on the variability in the investor sentiment variation is very high for the VIX index during the tranquil period.

Impact of Returns on Investor Sentiment Variation

In the previous sections, we examined the impact of investor sentiment variation on returns and volatility. In this section, we study the effect of returns shocks on the investor sentiment variation by examining the forecast error variance decomposition estimated from the VAR model. Table 3 presents the percentages of the forecast error of the investor sentiment variation that can be explained by returns at different horizons from 1 day to 10 days. Panel A reports the results for the tranquil period, and Panel B reports the results during the subprime crisis.

Table 2
Impact of investor sentiment variation on volatility

	Panel A: Tranquil period			Panel B: During subprime crisis		
	VIX	VXN	(Put-Call) Ratio	VIX	VXN	(Put-Call) Ratio
w	2.73E-07**	2.23E-07*	9.49E-07	4.29E-06**	4.52E-06**	7.86E-06*
	(3.4145)	(1.9949)	(1.3966)	(3.0926)	(2.5891)	(2.1775)
α_0	0.0201**	0.0276**	0.0223**	0.0265**	0.0440**	0.1125**
	(5.0357)	(5.6618)	(2.6354)	(2.6867)	(2.6333)	(3.3770)
β_1	0.9769**	0.9711**	0.9559**	0.9559**	0.9384**	0.8706**
	(223.3971)	(180.0053)	(45.3081)	(84.5056)	(54.3377)	(23.7284)
β_2	1.19E-05**	6.52E-06**	6.97E-05**	3.40E-05**	3.74E-05**	1.06E-05
	(11.6910)	(9.5235)	(4.9609)	(7.3876)	(6.2055)	(0.0847)

*, **, denote significant at the 5% and 1% levels respectively. *t*-statistic is reported into parenthesis.

Table 3
Variance decomposition of investor sentiment measures

	Panel A: Tranquil period			Panel B: During subprime crisis		
Horizon	VIX	VXN	(Put-Call) Ratio	VIX	VXN	(Put-Call) Ratio
1	63.4368	0.0213	10.8777	0.5919	2.3068	1.3955
2	63.5178	0.0238	8.4128	3.2227	6.7444	16.9521
3	63.6892	0.0601	9.5197	11.4199	14.8960	18.3594
4	63.6902	0.0602	9.9328	15.6286	18.8576	19.4743
5	63.6907	0.0603	9.8871	17.7601	20.9146	20.2493
6	63.6907	0.0603	9.9000	19.4935	22.5245	20.2517
7	63.6907	0.0603	9.9102	20.9073	23.8058	20.2956
8	63.6907	0.0603	9.9099	22.0124	24.8051	20.3125
9	63.6907	0.0603	9.9098	22.9272	25.6278	20.3123
10	63.6907	0.0603	9.9100	23.7084	26.3260	20.3131

Variance decomposition results suggest that returns shocks present an important source of daily volatility of investor sentiment variation during the subprime crisis period. This effect increases with the increase in the horizon, For a 1-day horizon, this effect is slightly less than 3%. However, for a 10-day horizon, return shocks present more than 20% of the variance in investor sentiment variation measured by the VIX, VXN and put-call ratio. This high effect during the subprime crisis is observed in the high frequency of negative returns. Indeed, the dramatic decrease in stock prices significantly affects the

investor's feelings and emotions. Consequently, returns shocks imply considerable volatility of investor sentiment variation.

Volatility Spillover between Investor Sentiment and Returns

To investigate the role of American investor sentiment in the amplification of the subprime crisis, we examine the spillover of volatility between investor sentiment and returns before and during the subprime crisis. Thus, we estimate the bivariate BEKK-GARCH model. Table 4 presents the estimated results of the mean and variance spillover. Panel A reports the results during the tranquil period, and Panel B reports the results during the subprime crisis period.

The results indicate that the coefficient λ_{12} measuring the mean spillover from the investor sentiment on returns is not significant before and during the subprime crisis for all measures of sentiment, except for the put-call ratio before the crisis. Considering these results, we can conclude there is an insignificant effect of investor sentiment on returns. These results confirm those of Brown and Cliff (2004). These authors found that investor sentiment weakly explains returns, although investor sentiment and returns are highly correlated.

The analysis of the mean spillover between returns and investor sentiment shows that there is clear evidence of mean spillover from returns to investor sentiment before and during the subprime crisis, except for the VIX index before the crisis. Consequently, return shocks significantly affect investor sentiment. From these results, we can conclude that the mean spillover is unidirectional from returns to investor sentiment.

Table 4 indicates that returns were negatively affected by their own shocks during the subprime crisis. Indeed, the coefficient, which assesses the mean spillover from returns to returns, was significantly negative during the subprime crisis period.

In the same sense, we find that the fluctuation of current investor sentiment significantly affects the future sentiment before the subprime crisis. Indeed, the coefficients of all sentiment measures are significant. The positive mean spillover from the past VIX (VXN) to the future VIX (VXN) suggests that investors use the past implied volatility to predict future volatility. Thus, we confirm the existence of extrapolation bias in the US financial market.

Significant GARCH coefficients β_{12} indicate significant spillovers from sentiment to returns before and during subprime crisis. Moreover, the volatility spillover is more pronounced during the subprime crisis than before. Results indicate that volatility spillover running from the put-call ratio to returns is equal

to 0.3 during subprime crisis, while it is 0.07 during the tranquil period. This finding can be explained by the lack of confidence of the American investor in financial markets during the current crisis, which is caused by fear and panic towards dramatic negative returns.

Table 4
Mean and variance spillover between investor sentiment and returns

	Panel A: Tranquil period			Panel B: During subprime crisis		
	S&P 500 VIX	S&P 500 VXN	S&P 500 (Put/Call) Ratio	S&P 500 VIX	S&P 500 VXN	S&P 500 (Put/Call) Ratio
			Mean spillover			
λ_{11}	0.0115	0.0302	–0.0356	–0.191***	–0.063	–0.193***
	(0.5411)	(–1.3083)	– (1.0323)	(–3.3917)	(–0.7699)	(–3.5128)
λ_{12}	–0.0281	–0.0407	0.3962**	–0.3075	0.4607	0.0141
	(–0.3242)	(–0.7546)	(2.1308)	(–1.1281)	(0.3715)	(0.5143)
λ_{21}	0.0072***	0.0073***	–0.0242***	–0.0088	0.0010***	–0.1507**
	(10.3259)	(8.7669)	(–5.0879)	(–1.1999)	(11.2914)	(–2.0478)
λ_{22}	0.9832***	0.9921***	0.3082***	–0.0224	0.9818***	0.0112
	(262.4950)	(419.6021)	(9.7870)	(–0.4760)	(696.6807)	(0.2356)
			Variance spillover			
α_{11}	0.0223	0.0555	0.1470*	0.3336***	–0.0654	0.3357***
	(0.4515)	(0.9383)	(1.7596)	(9.1151)	(–0.6566)	(8.4012)
α_{12}	0.0050***	0.0042***	–0.0219***	–0.0105	0.0012***	–0.1536
	(4.0458)	(2.6059)	(–3.8958)	(–0.9281)	(10.0049)	(–1.3547)
α_{21}	0.1204	3.8676***	1.3213**	0.6882*	–13.821	0.0369
	(0.1657)	(3.0167)	(2.5515)	(1.9152)	(–0.6351)	(1.2636)
α_{22}	0.3762***	0.2833***	0.0577	0.0707	1.0635***	0.1893
	(14.4703)	(8.2952)	(1.3928)	(0.5431)	(22.1958)	(1.5819)
β_{11}	0.7337***	0.6330***	–0.6447***	0.9335***	–0.7906***	0.9366***
	(192.3529)	(4.9858)	(–3.9655)	(55.1110)	(–6.3267)	(68.4920)
β_{12}	0.0065***	0.0081***	0.0752***	0.0299**	0.0007***	0.3089***
	(107.4314)	(3.7780)	(3.4891)	(2.4504)	(4.8315)	(3.1634)
β_{21}	0.6224	–1.0700**	–0.5854	–0.1338	27.2785	–0.0198
	(1.6341)	(–2.2185)	(–0.5346)	(–0.2166)	(1.4106)	(–0.4761)
β_{22}	0.8953***	0.9378***	1.0081***	–0.2422	–0.0234	–0.3205
	(82.0259)	(72.7723)	(23.4669)	(–0.4625)	(–1.1722)	(–0.9937)

*, **, denote significant at the 5% and 1% levels respectively. *t*-statistic is reported into parenthesis.

The spillover of pessimism sentiment to returns during the subprime crisis led to an increase of return volatility in the American financial market. This result suggests that the investor sentiment exhibits a determinant role in the amplification of the current financial crisis and constitutes a channel of volatility transmission.

Overall, the volatility spillover is unidirectional from investor sentiment to returns. Similarly, the mean spillover is unidirectional from returns to investor sentiment.

CONCLUSION

The financial markets have witnessed a serious decline of stock market prices during the subprime financial crisis, which caused a disruption of US investor sentiment. Indeed, the US financial markets have experienced a remarkable pessimism. In this paper, we empirically investigate the volatility spillover between American investor sentiment and returns, particularly during the subprime crisis period.

The analysis of the time path of investor sentiment measures and S&P 500 index prices reveals that the decline in prices during the subprime crisis is associated with a disruption of investor sentiment (increase of VIX and VXN indexes). Moreover, we show that the dynamic conditional correlation between investor sentiment measures and returns is negative and very high during a period of turmoil.

Our assessment of the impact of investor sentiment changes on returns indicates that the variation in sentiment significantly influences returns. Moreover, this effect is higher during the subprime crisis than during the tranquil period. The augmented GARCH model is estimated to test the impact of the change in investor sentiment on the volatility of return. We clearly find that the change in investor sentiment significantly affects volatility, particularly during the subprime crisis. Indeed, the panic and fear sentiments towards the impact of subprime crisis in financial markets reinforce investors to rapidly sell their stocks. Therefore, American investor sentiment provides an important ability in decreasing stock prices and consequently increasing volatility. Furthermore, this dramatic decrease in stock prices significantly affects the investor's feelings and emotions. Indeed, the variance decomposition results clearly show that returns shocks present an important source of volatility of investor sentiment variation during the subprime crisis period.

The analysis of volatility spillover between investor sentiment and S&P 500 returns, conducted by estimating the BEKK-GARCH model, suggests that investor sentiment plays a determinant role in the spillover of volatility to returns during subprime crisis, implying a high volatility of returns. In addition, we find a unidirectional mean spillover from returns to investor sentiment.

These results are important to individual and institutional investors. They can use the sentiment indicators to predict volatility of returns in financial markets, especially during crisis periods.

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